Application of Water Resources Management Mitigation Practices in the Southwestern Desert Region of The United States

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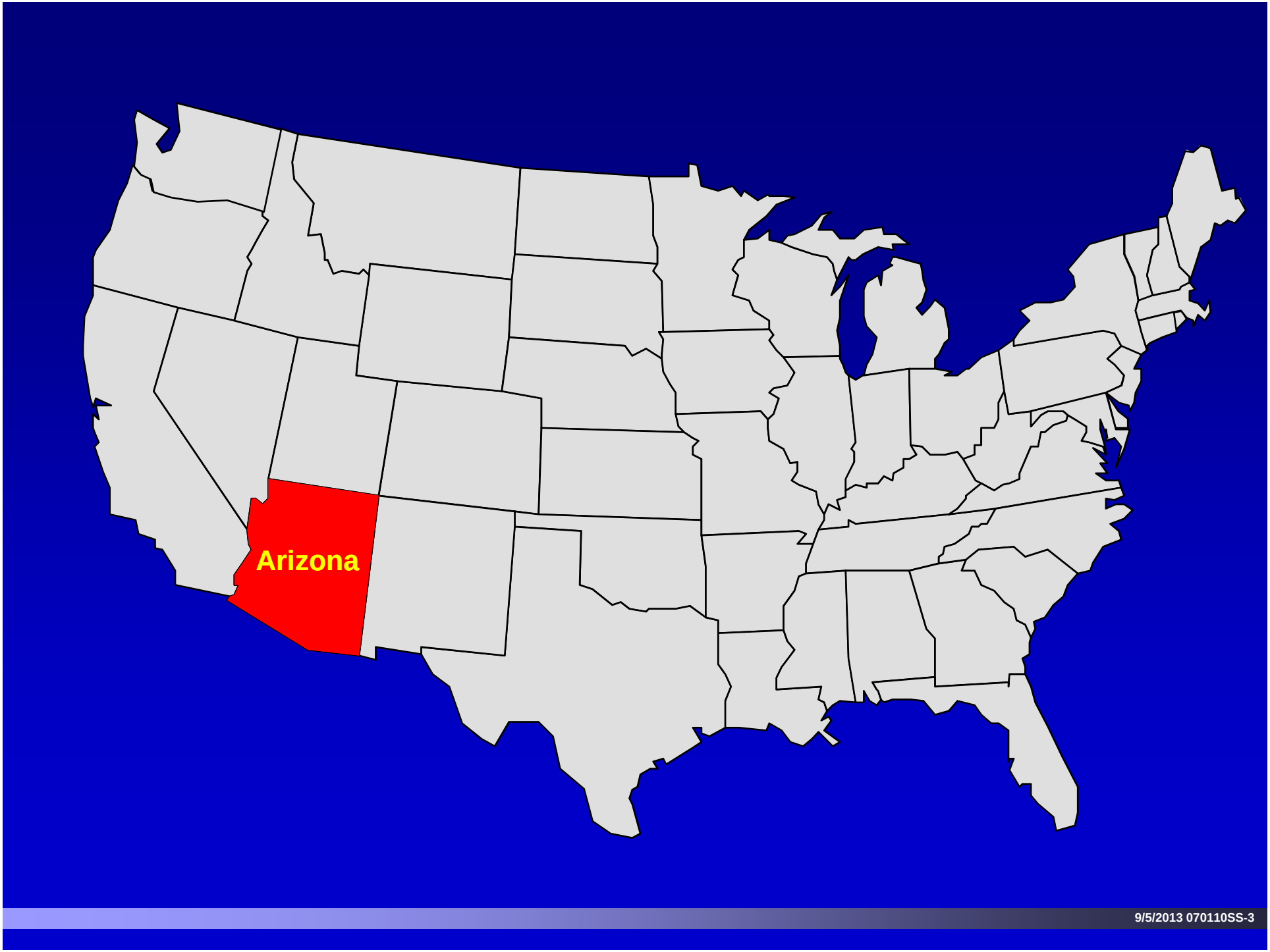
Arizona

Estado Del Gran Cañon Del Colorado

The Grand Canyon State

Bienvenidos Amigos

Welcome


Arizona
9/5/2013 070110SS-3

Phoenix

The Southwest Desert Region

- Arizona
- California
- New Mexico
- Nevada
- Utah


Nevada
Utah
California
Arizona
New Mexico

Climate and Water Distribution

Climate - Semiarid

Surface Water – Seasonal and limited

- **Winter: Pacific fronts – major**
- **Summer: Tropical fronts – minor**
- **El Niño: Dry / La Niño / wet**
- **Major drainages:**
  - **Colorado River – Rocky Mountains**
  - **Rio Grande – Rocky Mountains**
  - **San Joaquin and San Fernando Rivers – Sierra Nevada**

Groundwater – Uneven geographic distribution

- **In low desert region: Alluvial**
- **In mountains and Colorado Plateau: Bedrock aquifers**

Regional Historic Water Use

Late 1800s to mid 1900s

Development of Agriculture

The Reclamation Act

Large Irrigation Projects (U.S.B.R.)

The Salt River Project

Intensive use of groundwater

Ag. chemicals pollute groundwater: NO3, DBCP, EDB

Mid 1900s to Present

Los Angeles, San Diego, Phoenix, Las Vegas, Albuquerque, Salt Lake City, Tucson

Industry displaces agriculture as revenue source

Ag wells converted to potable wells

Industrial chemicals pollute groundwater: VOCs, gasoline

Roosevelt Dam

Groundwater Mining

Intense in the Agricultural Areas

Examples:

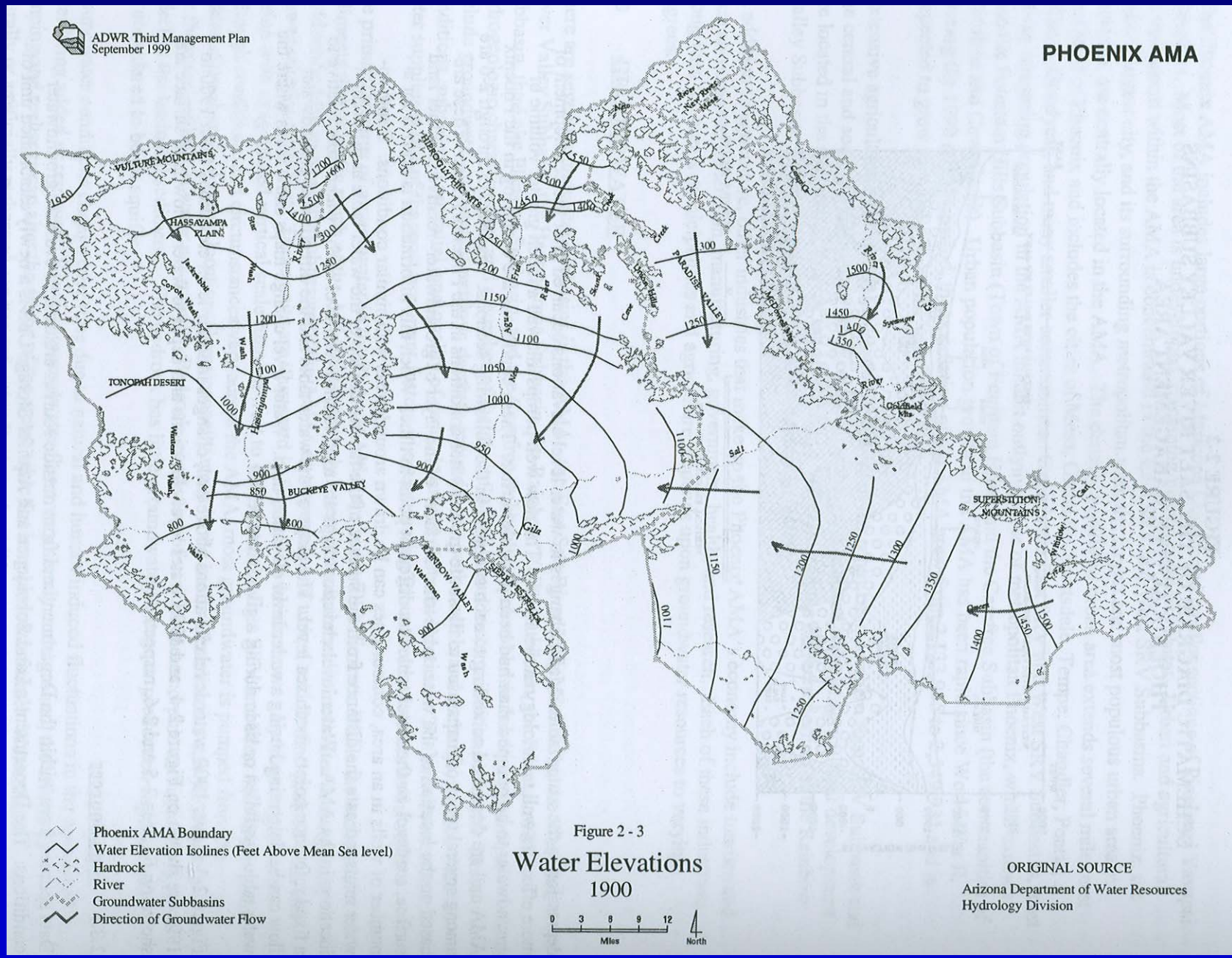
- Central Valley, Imperial Valley, CA
- Salt River Valley, Pinal County, AZ

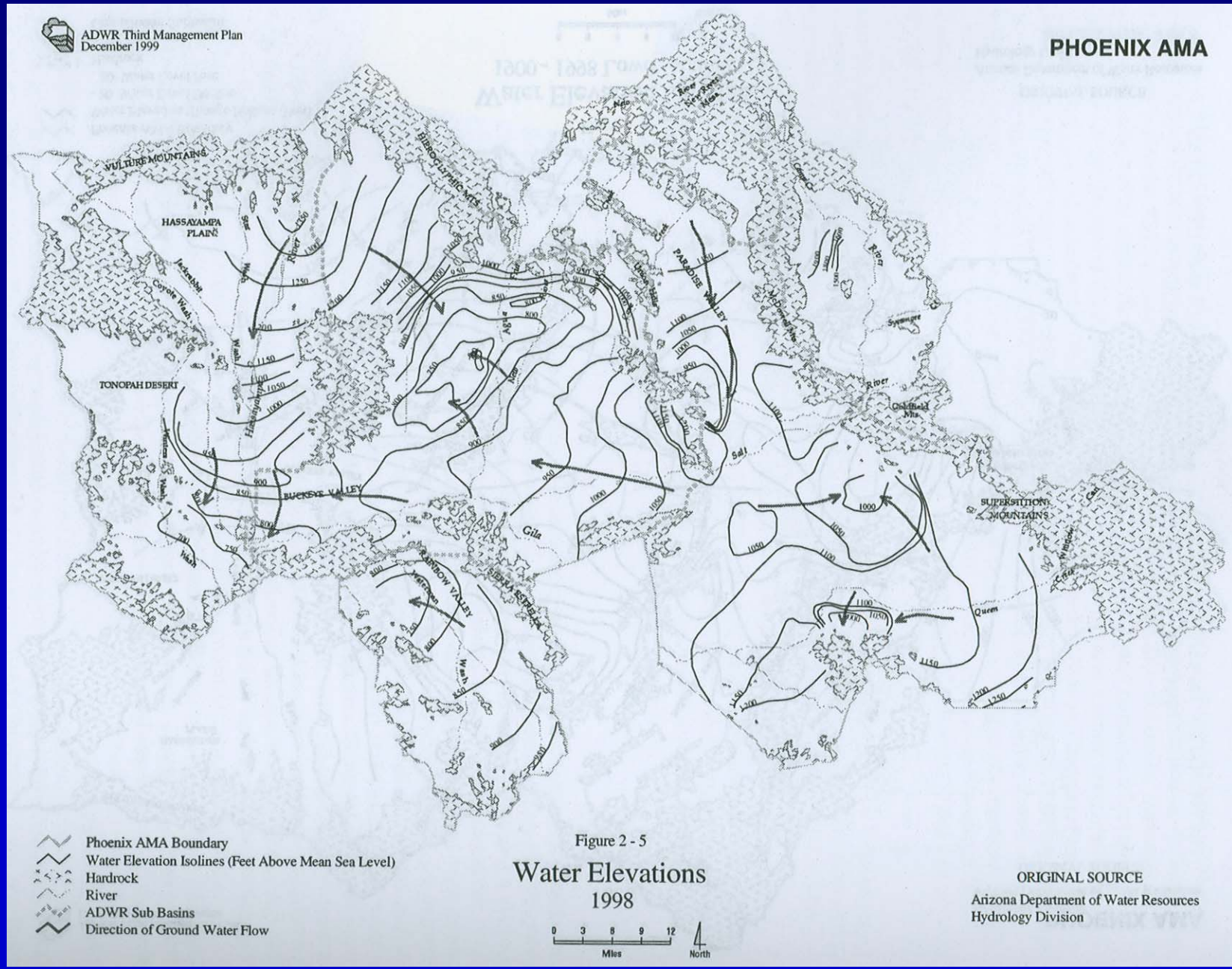
Unregulated Abstraction

Groundwater Mining

Effects

- **Aquifer depletion**
  - **Increase in pumping lift**
  - **Change of groundwater flow regime: cones of depression closed basins**
- **Land subsidence**
  - **Fissures**
  - **Infrastructure collapse**
- **Groundwater quality deterioration**


ADWR Third Management Plan
September 1999
PHOENIX AMA
VULTURE MOUNTAINS
HASSAYAMPA PLAIN
TONOPAH DESERT
BUCKEYE VALLEY
RAINBOW VALLEY
SIERRA ESTRELLA
PARADISE VALLEY
SUPERSTITION MOUNTAINS
Gila
Salt
Phoenix AMA Boundary
Water Elevation Isolines (Feet Above Mean Sea level)
Hardrock
River
Groundwater Subbasins
Direction of Groundwater Flow
Figure 2 - 3
Water Elevations
1900
0 3 8 9 12
Miles
North
ORIGINAL SOURCE
Arizona Department of Water Resources
Hydrology Division


ADWR Third Management Plan
December 1999
PHOENIX AMA
VULTURE MOUNTAINS
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Gila
Phoenix AMA Boundary
Water Elevation Isolines (Feet Above Mean Sea Level)
Hardrock
River
ADWR Sub Basins
Direction of Ground Water Flow
Figure 2 - 5
Water Elevations
1998
0 3 6 9 12
Miles
North
ORIGINAL SOURCE
Arizona Department of Water Resources
Hydrology Division

Applied Mitigation Practices for Aquifer Restoration

- Conservation
- Importation
- Augmentation and recharge
- Purchase and retirement of groundwater rights
- Re-use
- In situ and wellhead treatment
- Regulatory enforcement

The State of Arizona Groundwater Code

The Groundwater Management Act of 1980

- **Establishes Active Management Areas (AMA)**
- **Guides and mandates progressive reduction of groundwater use**
- **Promotes augmentation**
- **Encourages re-use**

Water Importation

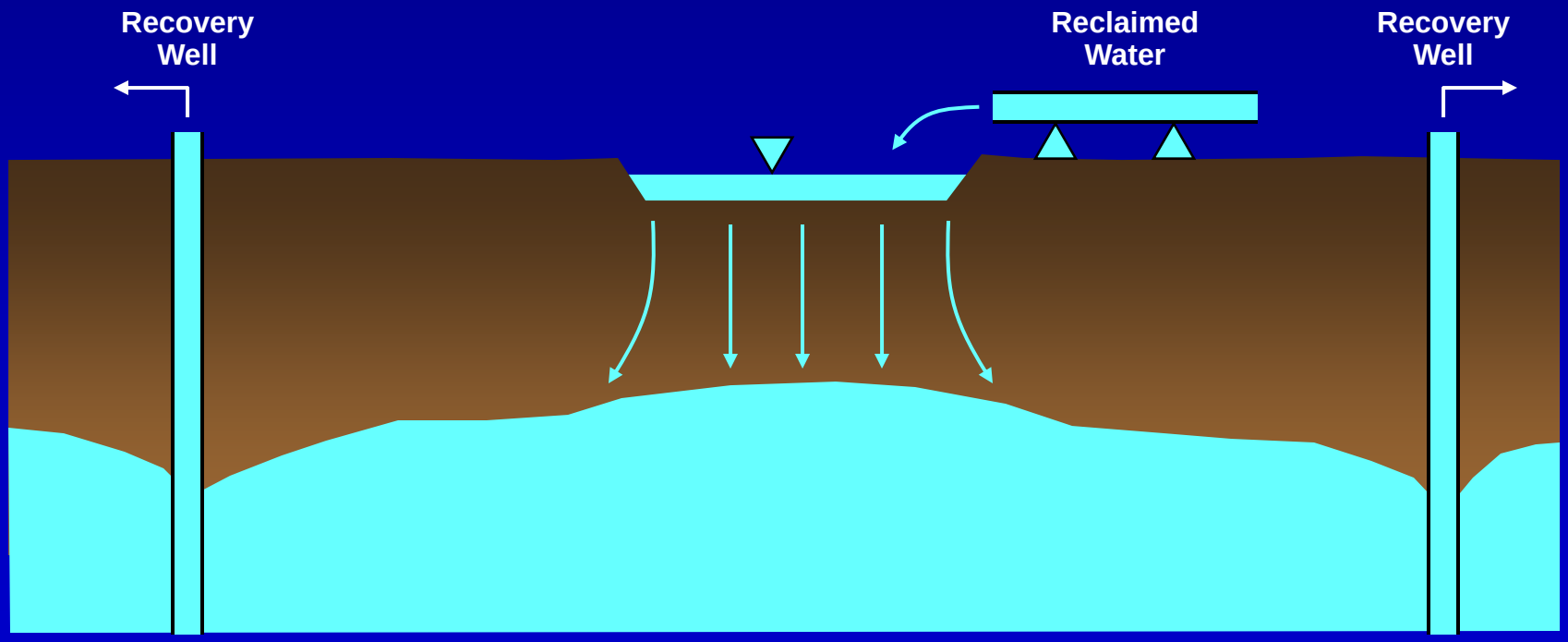
- Arizona, California, Nevada and Utah directly import water from the Colorado River. Arizona, California and Utah built large aqueducts
- Colorado River water is allocated to each state by agreement. Regulated by the federal government: The Law of the River
- Arizona vs. California: 1963 Supreme Court Decision
- In Arizona groundwater can not be exported from one basin to another basin

CAP Canal

Central Arizona Canal

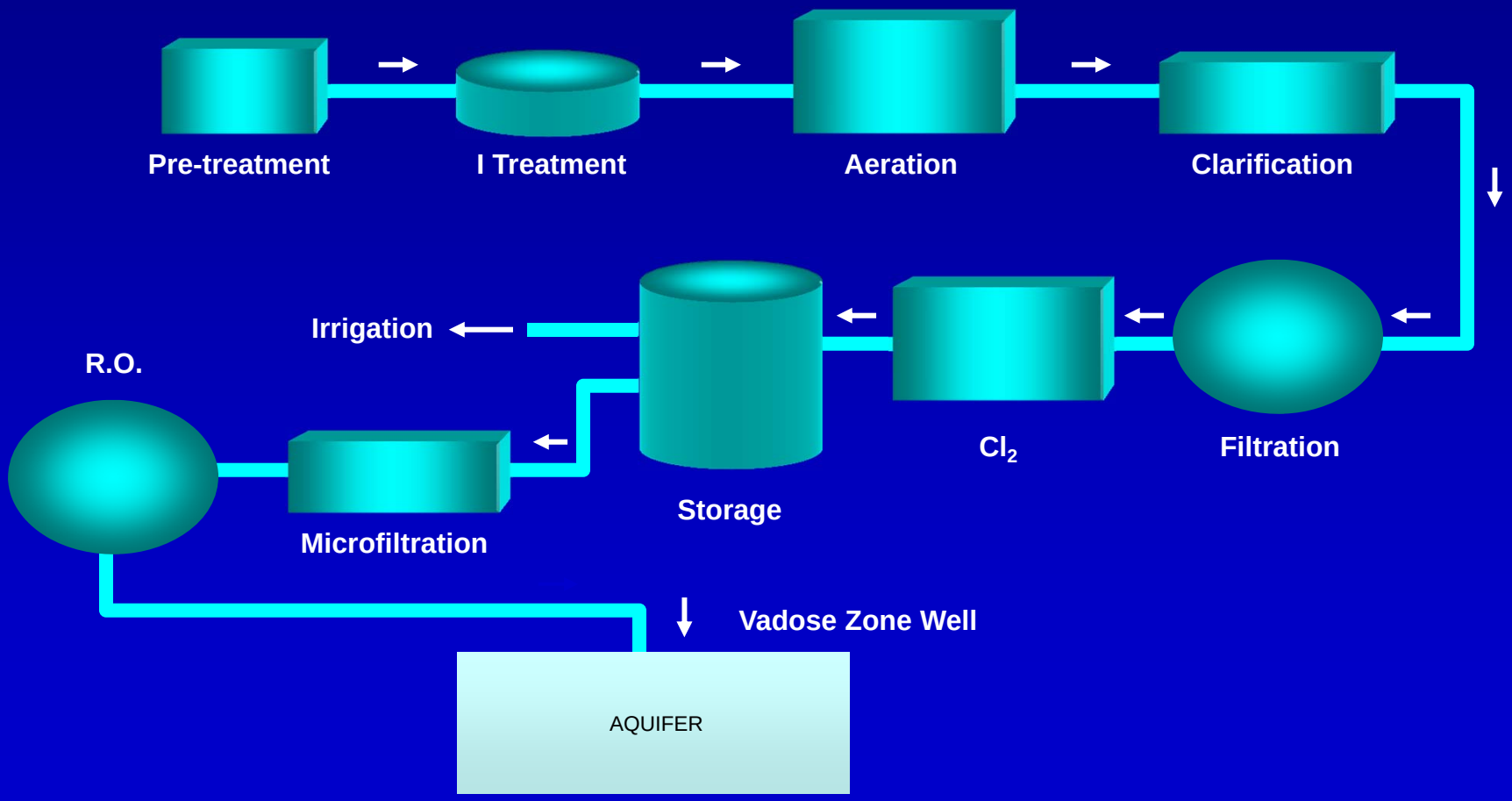
Water Re-Use

Soil Aquifer Treatment



Water Re-use in Phoenix

The Water Campus Facility



Augmentation and Groundwater Recharge

Conjunctive Use

Conjunctive Water Management

“Is the management of surface and groundwater resources in a coordinated operation to the end that the total yield of such a system over several years exceeds the sum of the yield of the separate components of the system that would result from uncoordinated operations"

Yields:

SW operation = A
GW operation = B
CWM operation = Z

$$Z > A + B$$

Conjunctive Use Management

Artificial Groundwater Recharge

Methods

- **Direct surface**
  - Channel modification – T/L levees
  - Basins – in-channel / off-channel
  - Pits / trenches
- **Direct subsurface**
  - Injection wells
  - Vadose zone (dry)wells

Conjunctive Use Management

Water Reuse

- Waste water treatment process
- Reclaimed water
  - Quality
  - Disposal
  - Permissible uses
  - Regulations
- Soil aquifer treatment
  - Methodology
  - Water recovery

Conjunctive Water Management

Objectives

- Increase yield
- Increase the reliability of supply
- Improve the efficiency of a water system

Procedure

Divert and convey surplus surface water when available for aquifer storage in basins for later use when surface water is scarce or not available

Methods of Conjunctive Use

Two Major Types

- **Alternative conjunctive use**
- **Comprehensive conjunctive use**

Alternative Conjunctive Use

In General

- **Dry weather cycle**
  - **Use of groundwater exceeds use of surface water**
- **Wet weather cycle**
  - **Use of surface water exceeds use of groundwater**

Comprehensive Conjunctive Use

System Components

- Surface storage – Dams/reservoirs
- Diversion elements
- Conveyance units
- Underground storage (recharge) facilities
- Abstraction (recovery units – wells
- Water treatment plants – W.T.P. and W.R.P.

Some components of the system may not be needed in the system or may be added later when the need arises example SRP

Comprehensive Conjunctive Use

Aquifer Storage is Essential

Aerial View of Two Orange Country Water District Percolation Ponds known as the Warner Basin and the “Little” Warren Basin

Comprehensive Conjunctive Use System

Comprehensive Conjunctive Use Projects: Types

- Stream diversions
- Dam and reservoirs
- Aqueducts
- Total system (dams, reservoirs and aqueducts)

Central Arizona Project

Features

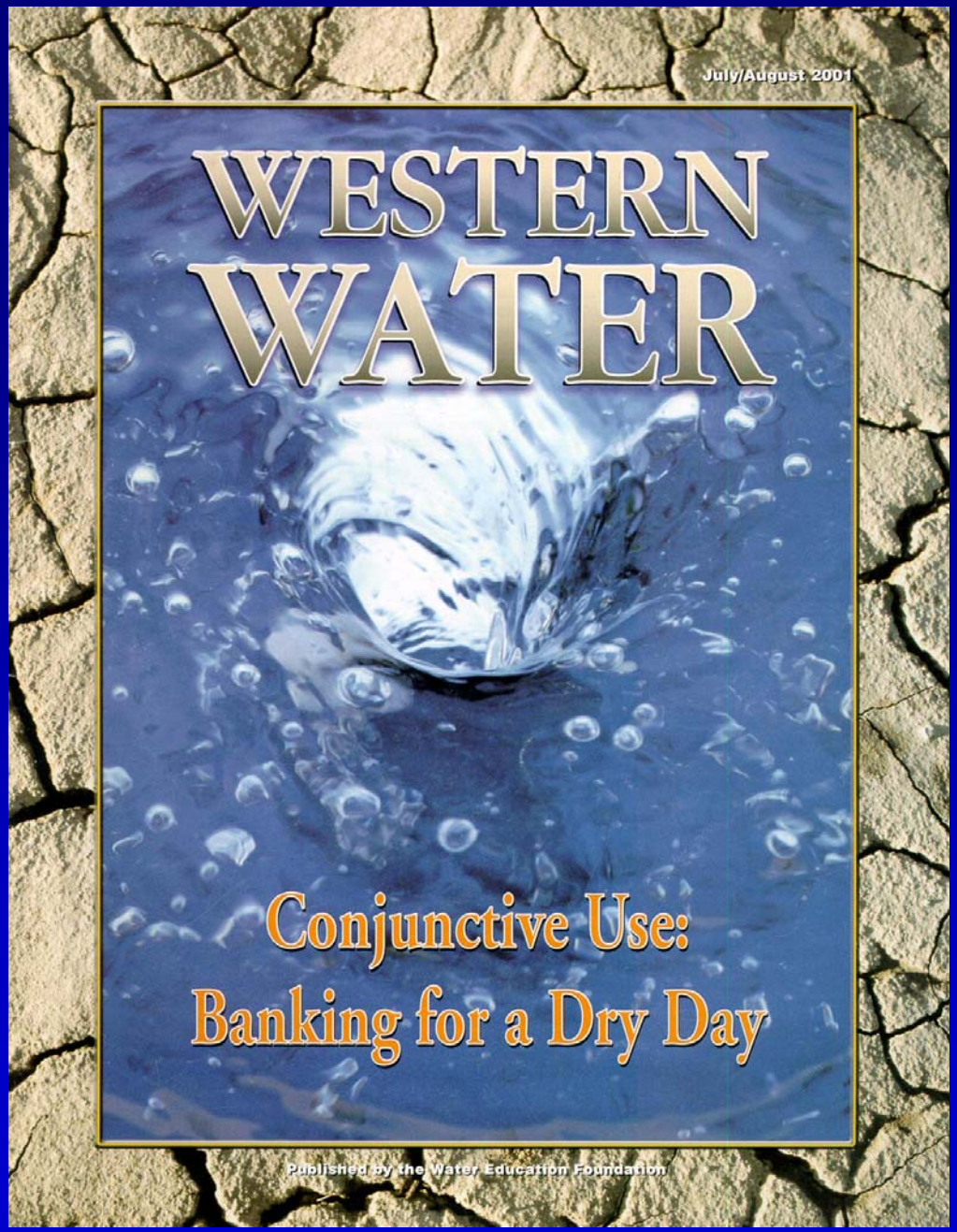
- Imports Colorado River water to central and southern Arizona
- Distributes Arizona's Colorado River water allocation
- A result of the Arizona vs. California law suit
- Operated and managed by a State Institution the Central Arizona Water Conservation District (CAWCD)
- Delivers water for irrigation and municipal use

Purpose

Securing a dependable water supply by *Water Banking*

Finalidad

Asegurar el suministro de agua de manera confiable usando el *'Banco de Aguas'*


July/August 2001
WESTERN WATER
Conjunctive Use:
Banking for a Dry Day
Published by the Water Education Foundation

Conjunctive Use in Nevada

Las Vegas Valley

- Supply for the city of Las Vegas – Very rapid population growth
- Two water sources
  - Colorado River water
  - Groundwater
- Colorado River water WTP on Lake Mead
  - For direct use
  - For groundwater recharge
- Water management entities
  - Southern Nevada Water Authority
    Las Vegas Valley Water District

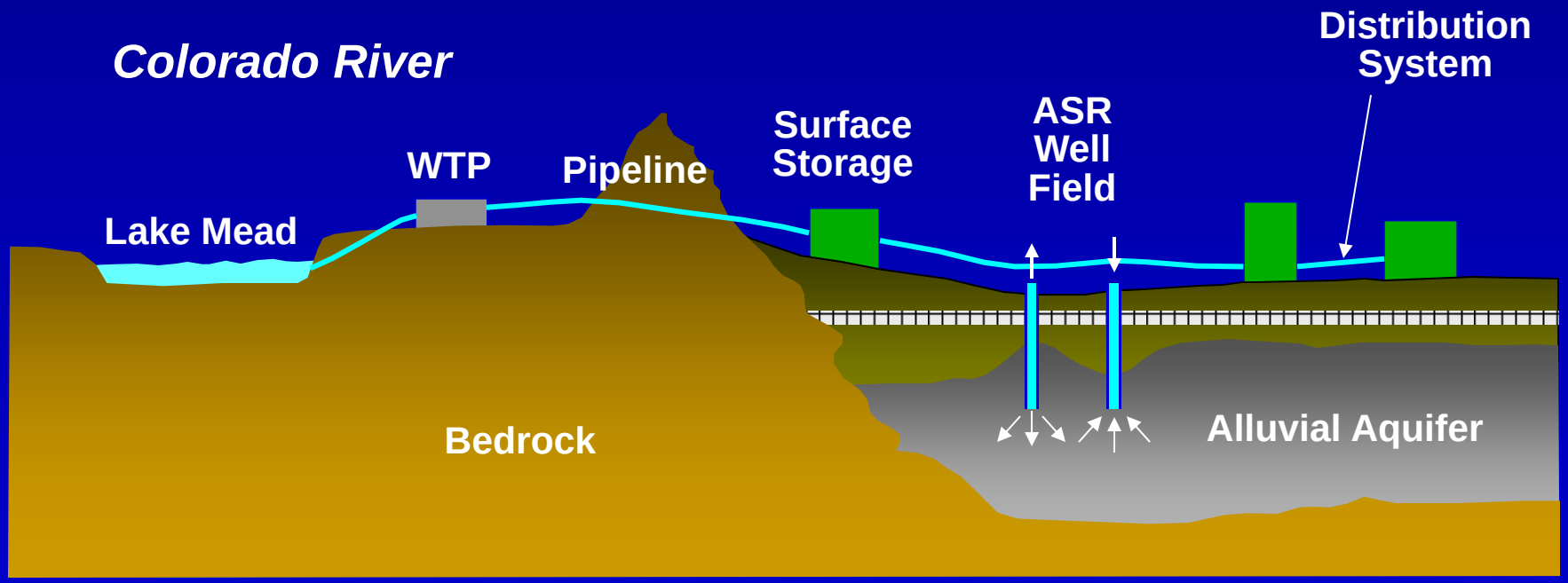

CAESARS
PALACE

Conjunctive Use in Nevada

- Use of ASR wells for recharge and recovery of surface water stored in the aquifer
- Recharge is predominantly done in the winter. Recovery in the summer
- No concerning impacts to the groundwater quality
- The largest ASR well field in the USA

Conjunctive Use in Nevada

City of Las Vegas




WELL 16
MEADOWS MALL PARKING LOT
Las Vegas Valley
Water District
258-3150

Conjunctive Water Management in Arizona

Conjunctive Use in Arizona

- **Tucson Metropolitan area: Lower Santa Cruz Valley**
  - **Population: 1.5 million**
  - **Annual precipitation: 180 – 210 mm/y**
- **Phoenix Metropolitan area: Salt River Valley**
  - **Population: 5 million**
  - **Annual precipitation: 150 – 200 mm/y**

Conjunctive Use in Arizona
Tucson

System Facilities for CAP Water

- CAP aqueduct
- 4 water-spreading recharge facilities
- One large well recharge field
- Water treatment plant

System Facilities for Reclaimed Water

- 2 large water reclamation plants
- One large recharge (water – spreading) facility
- One managed river discharge

System for Groundwater

- Several well fields

The Salt River Valley

Arizona

Salt River Valley

Water Resources Management System

Components

- SRP system
- CAP aqueduct
- Municipalities systems
  - Wells
  - Water treatment plants
  - Water distribution network
  - Water reclamation plants

Central Arizona Canal

The Salt River Project

Delivering More Than Power.®

Conjunctive Water Management by SRP

Irrigation

SRP

Water Resources Management System

Components

Surface Water

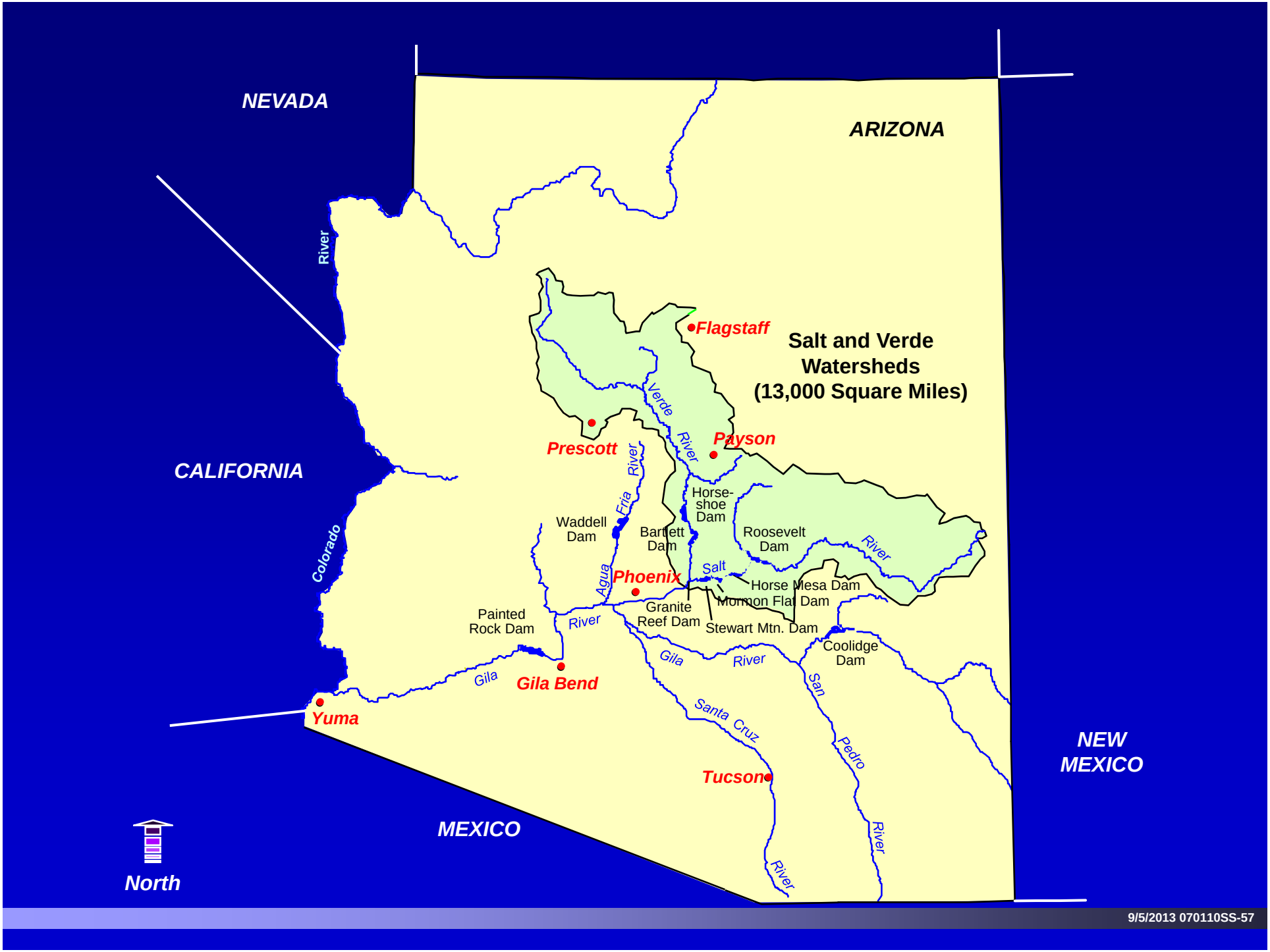
- Dams and reservoirs
- Water conveyance network: Canals and laterals
- Hydroelectric plants
- Measurement and monitoring network
- Operation and control stations

SRP

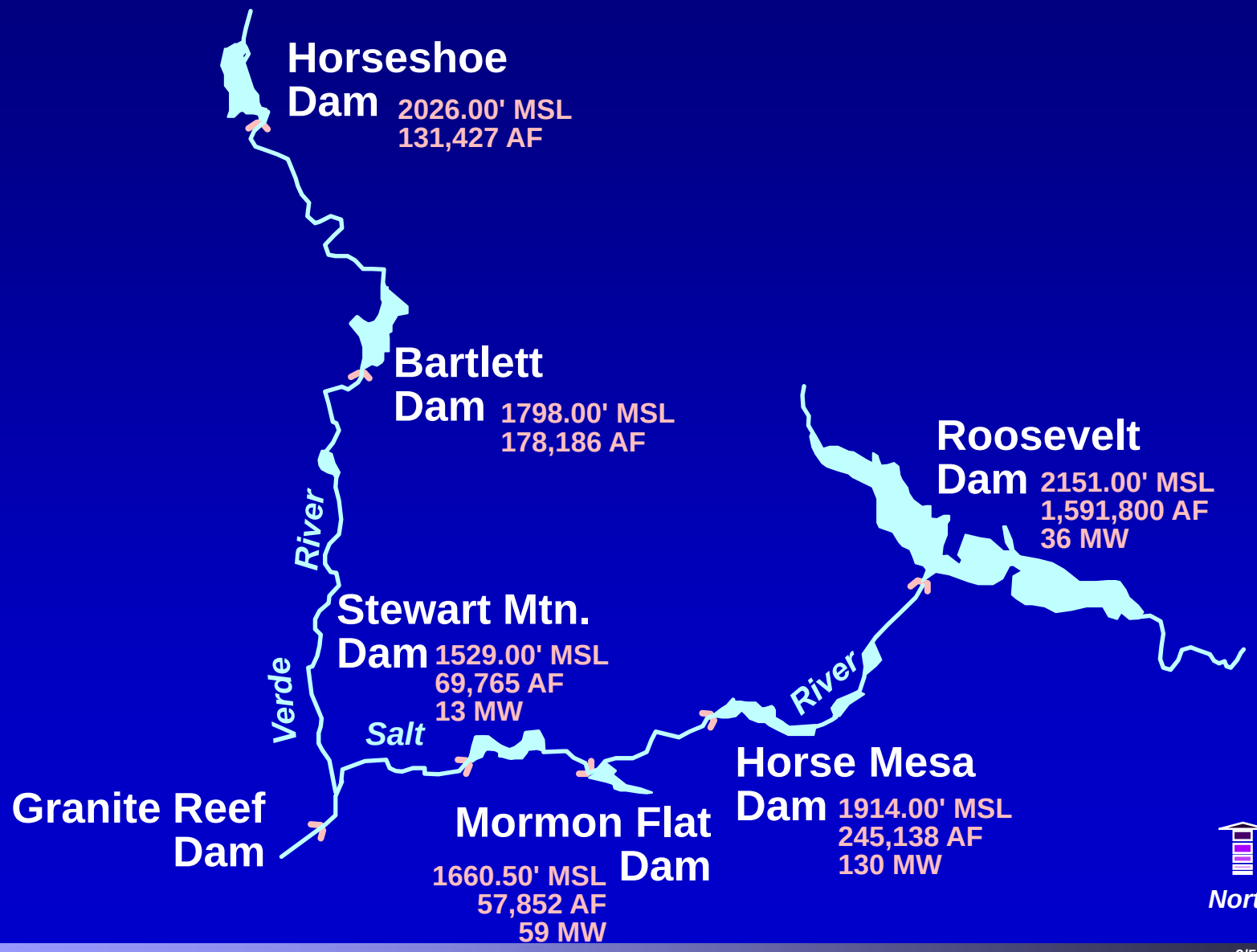
Water Resources Management System

Dams and Reservoirs

- **Verde River**
  - **Horseshoe – 162E6 M^3**
  - **Bartlett – 220E6 M^3**
- **Salt River**
  - **Roosevelt – 3,082.5E6 M^3**
  - **Horse Mesa – 302E6 M^3**
  - **Mormon Flat – 71E6 M^3**
  - **Stewart Mountain – 86E6 M^3**

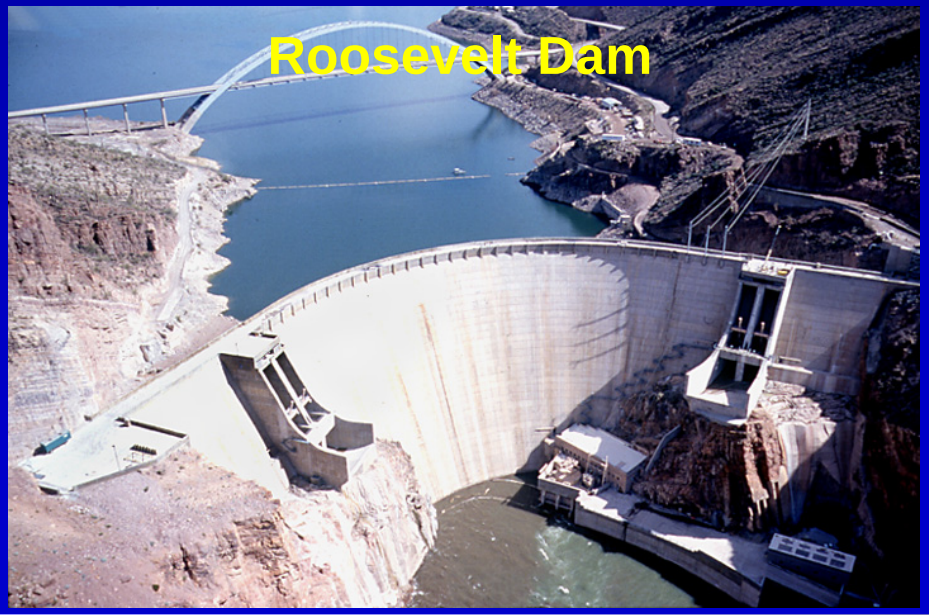

NEVADA
ARIZONA
CALIFORNIA
NEW MEXICO
MEXICO
Colorado River
Salt and Verde Watersheds (13,000 Square Miles)
Flagstaff
Prescott
Payson
Verde River
Fria River
Waddell Dam
Bartlett Dam
Horse-shoe Dam
Roosevelt Dam
Salt River
Agua
Phoenix
Horse Mesa Dam
Mormon Flat Dam
Granite Reef Dam
Stewart Mtn. Dam
Coolidge Dam
Painted Rock Dam
Gila River
Gila Bend
Yuma
Santa Cruz
San Pedro River
Tucson
North
9/5/2013 070110SS-57

Salt River Project Reservoir System

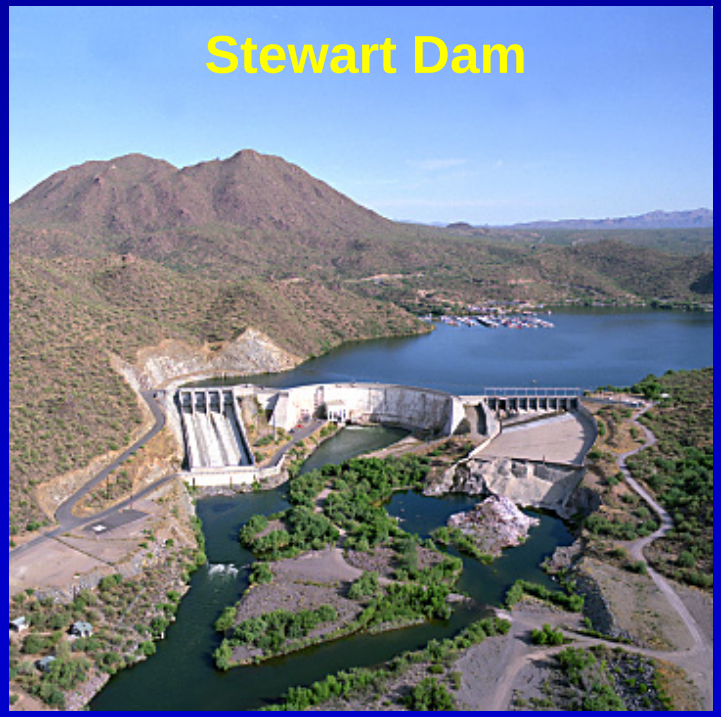


Mormon Flat Dam

Roosevelt Dam



Stewart Dam



SRP

Water Resources Management System

Water Conveyance

- Canal 210 KM
- Laterals 320 KM
- Total 530 KM

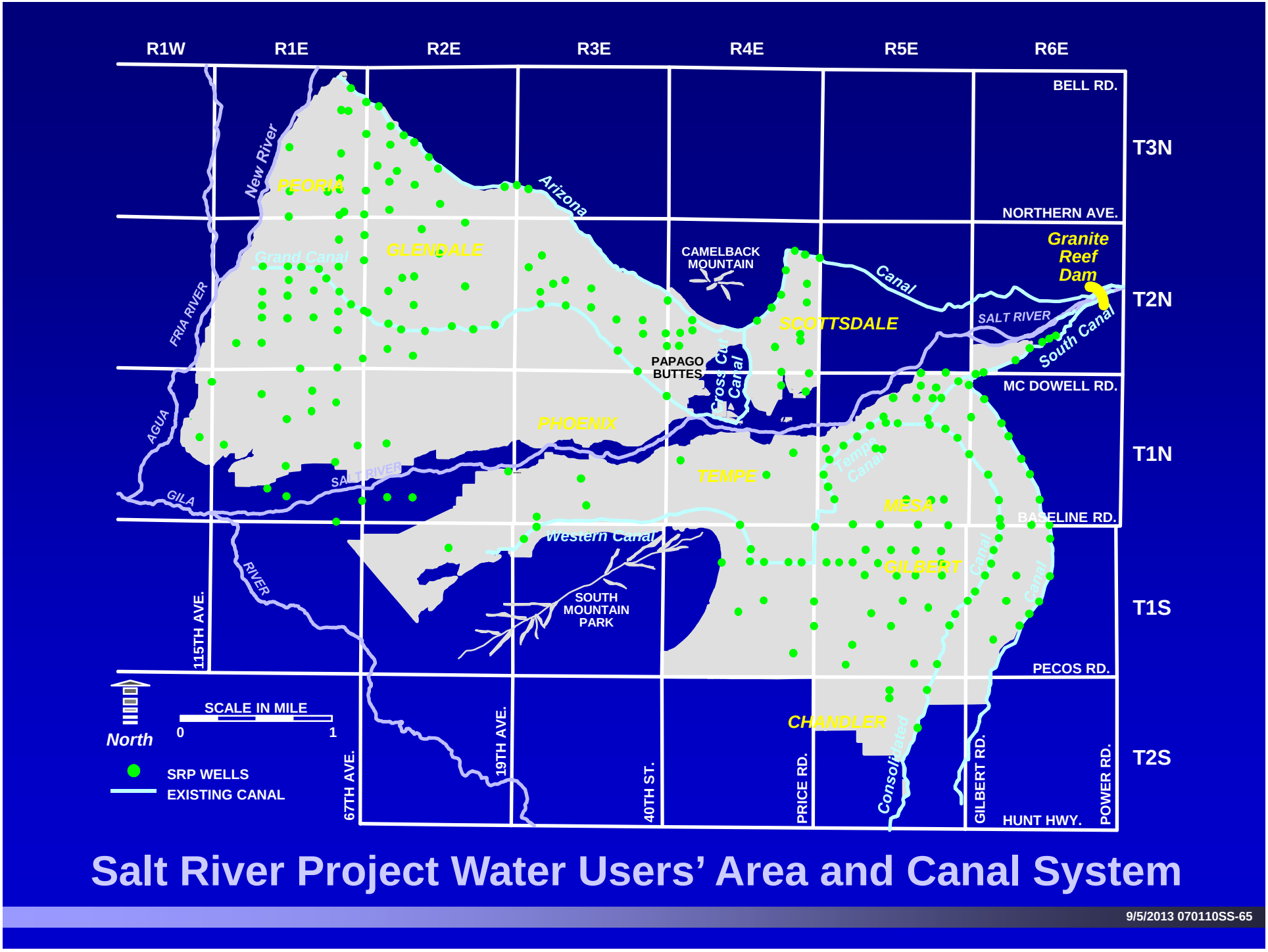
Arizona Canal

SRP

Water Resources Management System

Components

- **Groundwater**
  - **Wells – Production**
  - **Wells – Recharge**
  - **On site water treatment plants**
  - **Water spreading recharge projects**



Salt River Project Water Users' Area and Canal System

SRP

Water Resources Management System

Groundwater

- **Well**
  - 250 wells
  - Mean depth – 370M
  - Mean capacity – 180-200 L/S
- **Recharge**
  - GRUSP 1235E6 M^3 /Y
  - NAUSRP 302E6 M^3 /Y
  - Wells 12E6 M^3 /Y

SRP

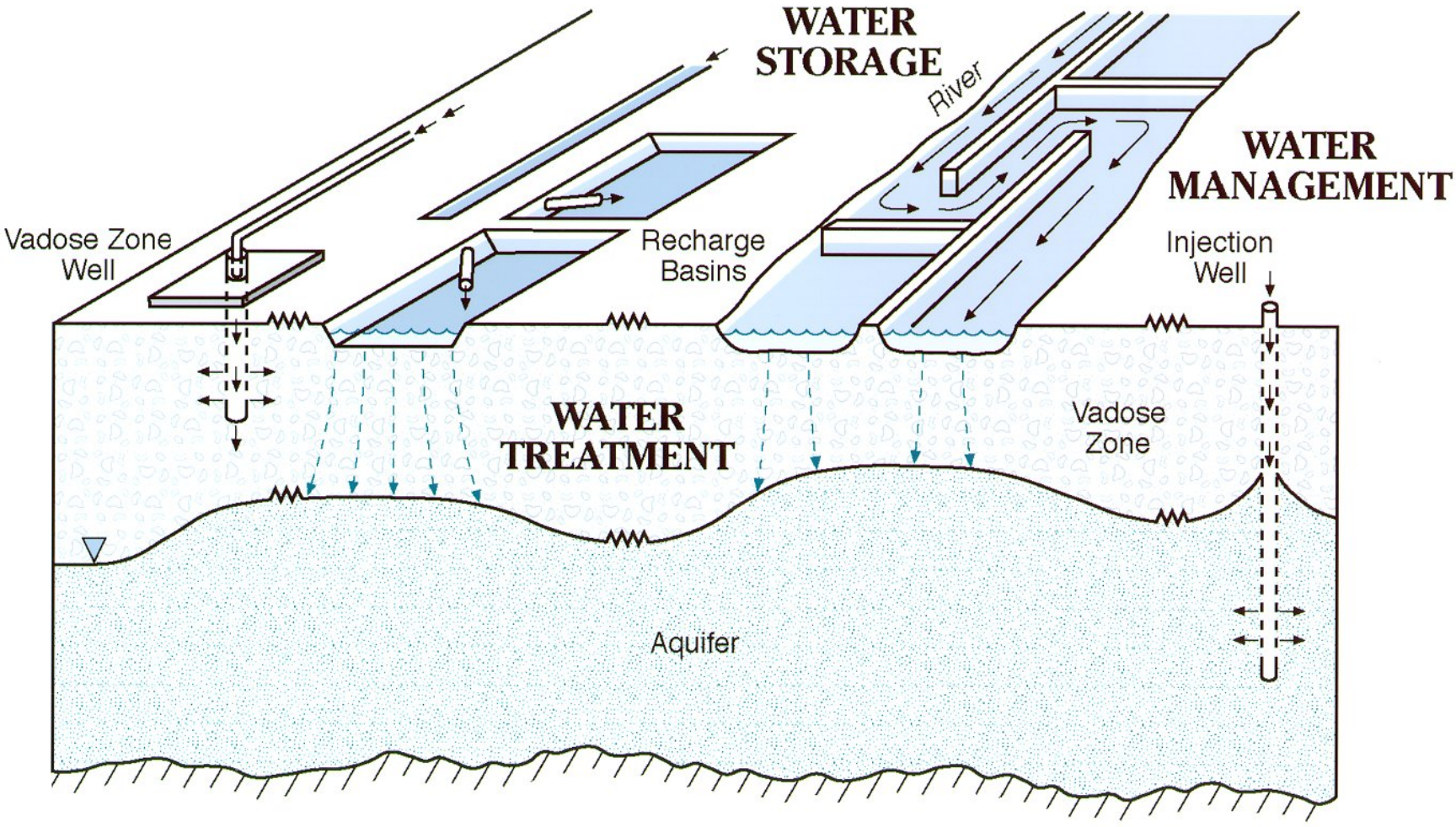
Water Resources Management System

Groundwater System

- **Total pumping capacity – 1.0E9 M^3/Y**
- **Total underground storage capacity – 260E6 M^3/Y**

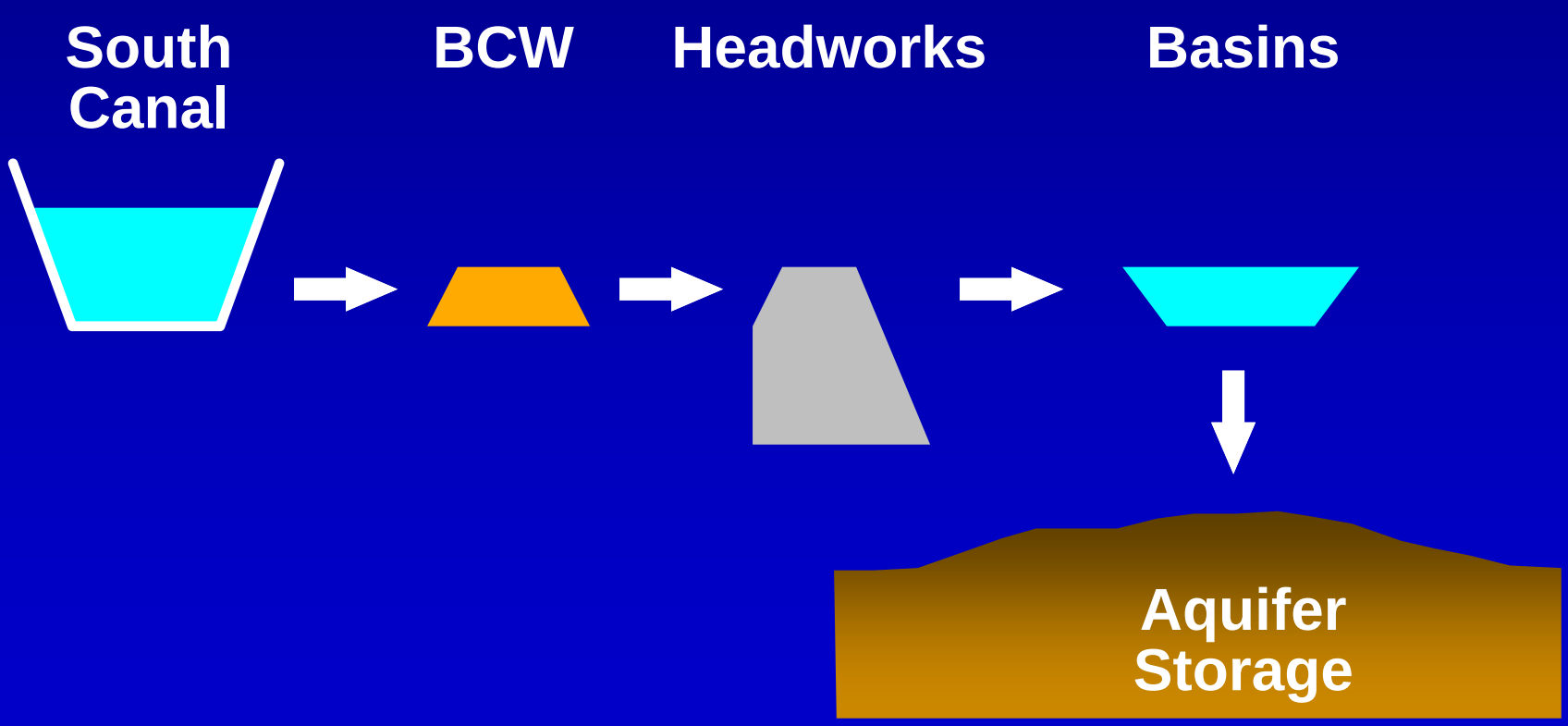

2453

GROUNDWATER RECHARGE



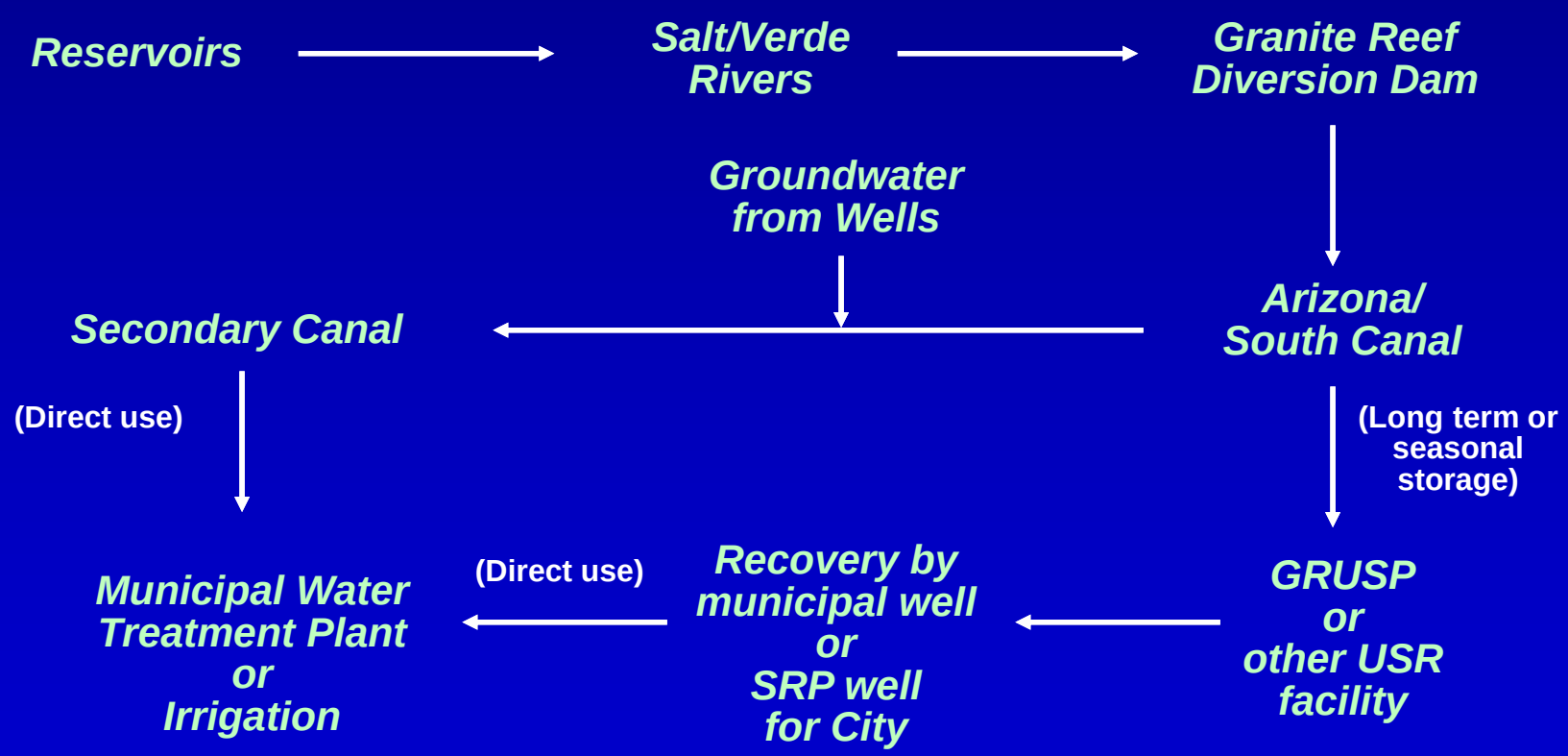
Granite Reef Underground Project, Phoenix, Arizona, USA. Aerial view of delivery and recharge components

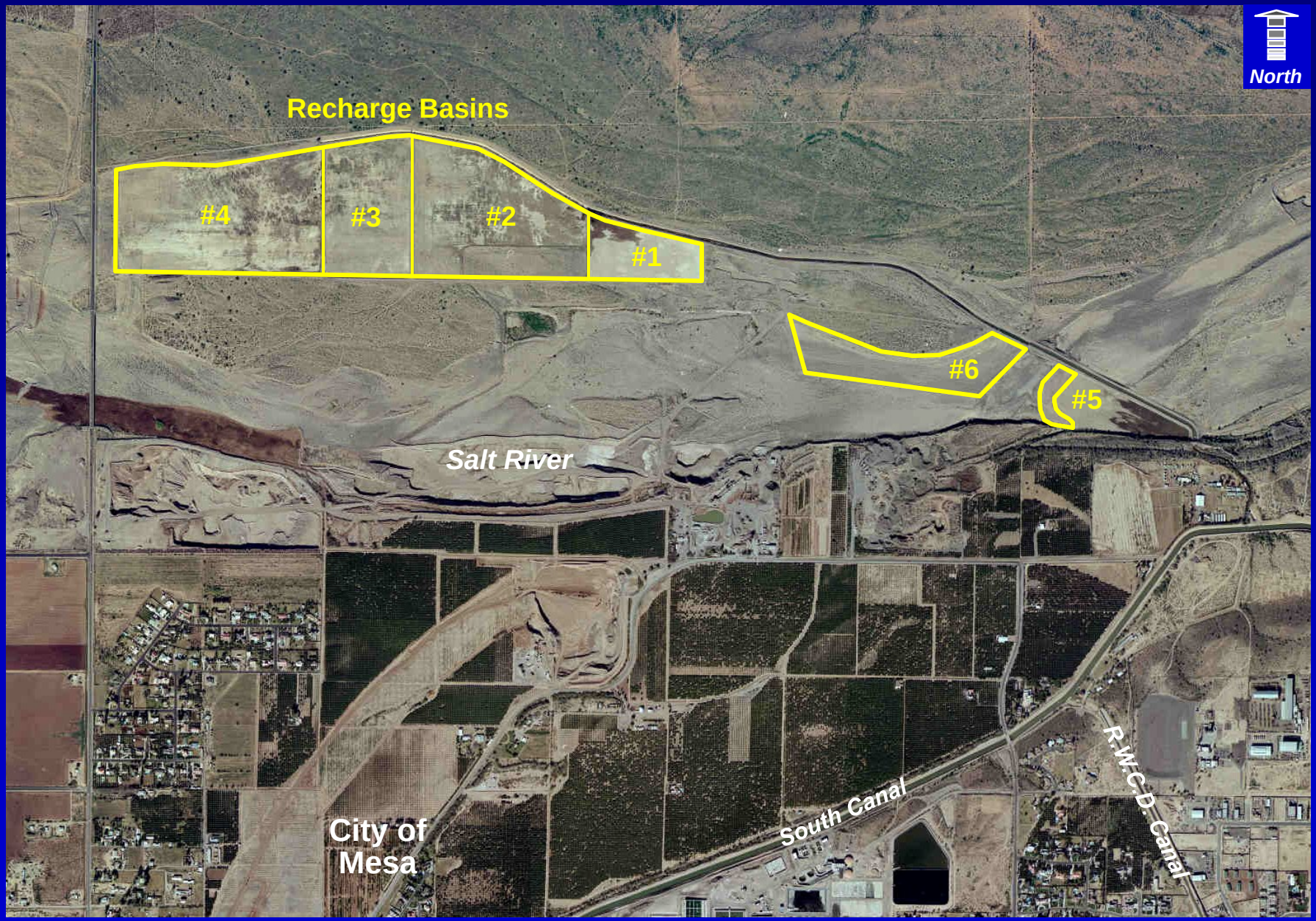
Recharge System Operation



Water Resources Management

SRP Water Order




Recharge Basins
#4
#3
#2
#1
#6
#5
North
Salt River
City of Mesa
South Canal
R.W.C.D. Canal

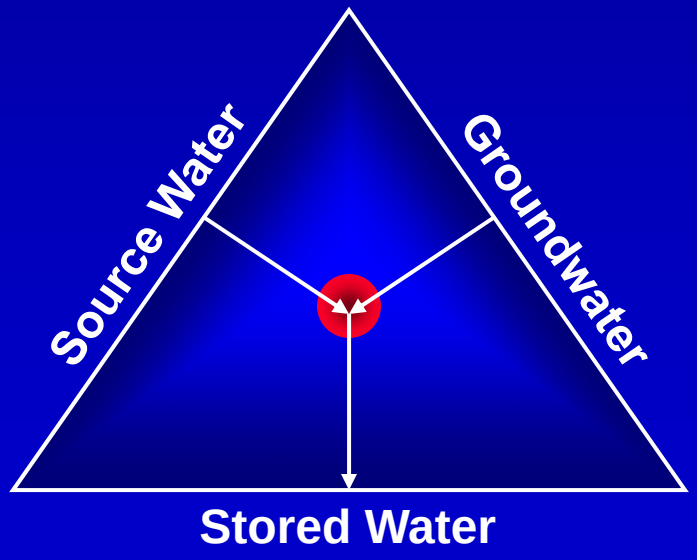
9/5/2013 070110SS-74

9/5/2013 070110SS-75

Groundwater Recharge Facilities

Compatibility

(Chemical + Physical + Biological)



SRP

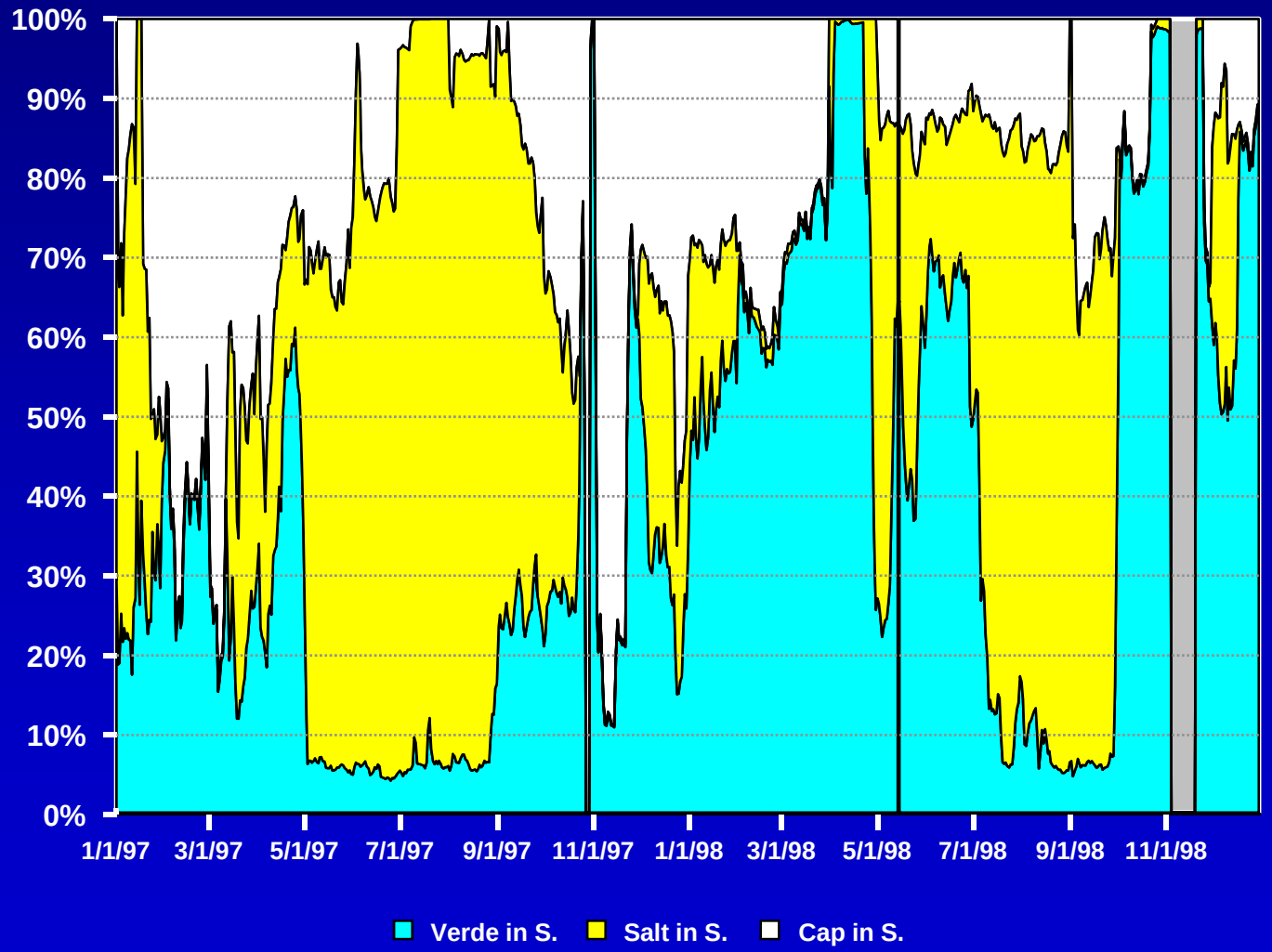
Management

The surface and groundwater system are fully integrated and operate as a single unit by Conjunctive Water Management

Water Sources

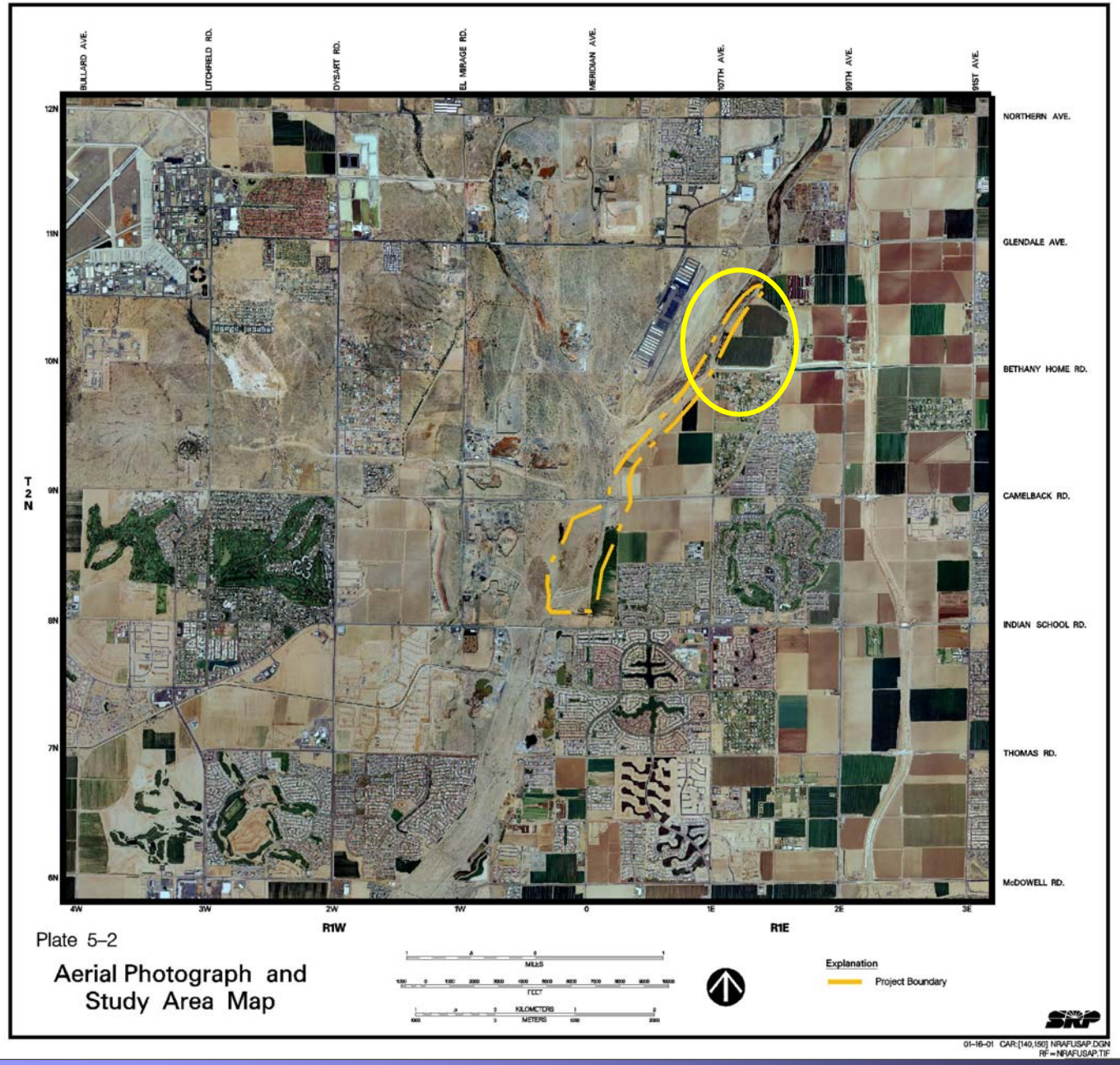
- **Salt and Verde Rivers Water**
- **Groundwater**
- **Central Arizona Project (CAP) Water**
- **Reclaimed Water (in the future)**

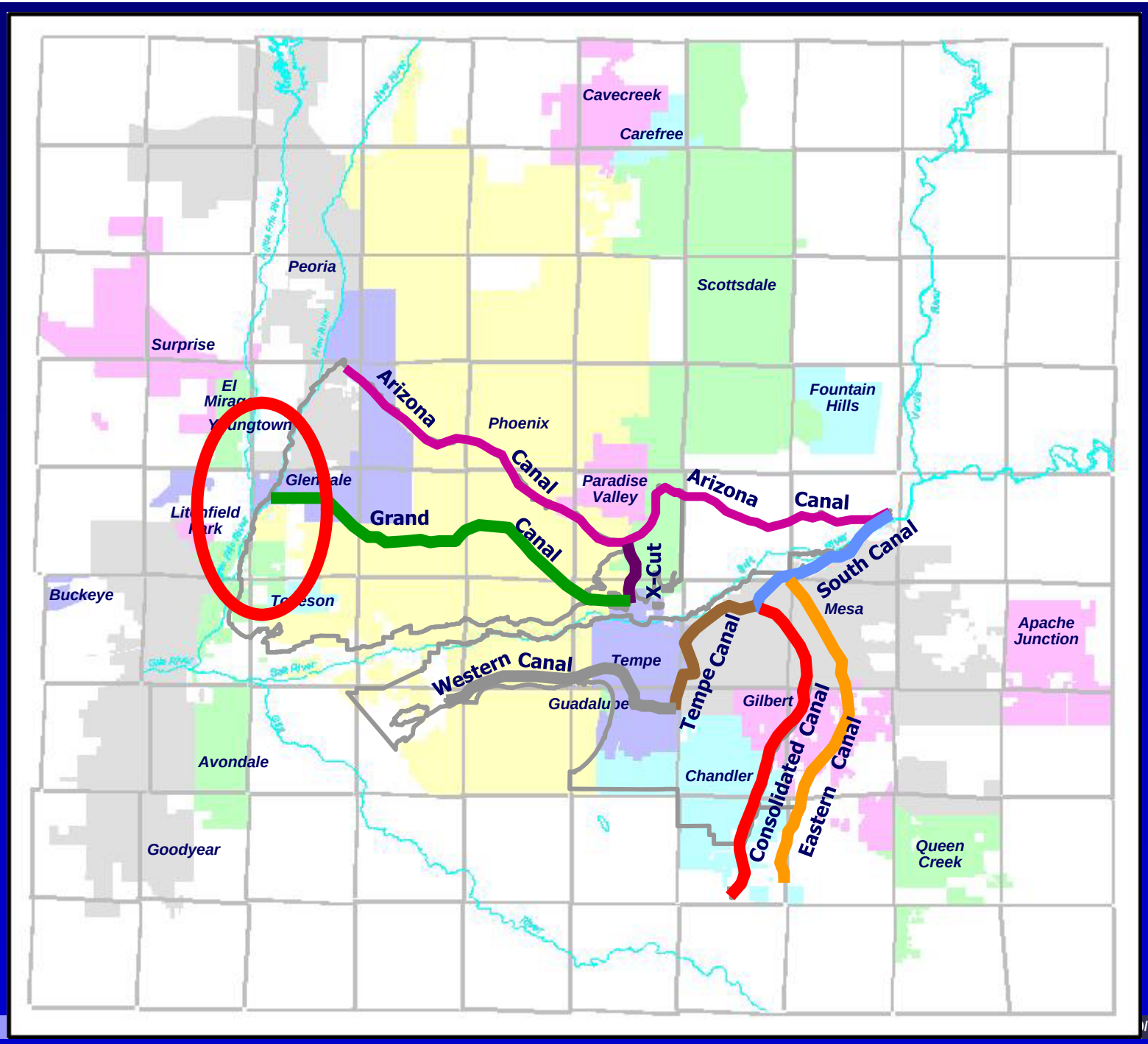
GRUSP Source Water Blending



Conjunctive Use in Arizona
NAUSP Facility

- Aquifer storage – Multi source
- For CAP, SRP and reclaimed water
- Capacity: 1,200 E6/y
- Interagency project


BULLARD AVE.
LITCHFIELD RD.
DYSART RD.
EL MIRAGE RD.
MERIDIAN AVE.
107TH AVE.
99TH AVE.
91ST AVE.
NORTHERN AVE.
GLENDALE AVE.
BETHANY HOME RD.
CAMELBACK RD.
INDIAN SCHOOL RD.
THOMAS RD.
McDOWELL RD.
12N
11N
10N
9N
8N
7N
6N
T 2 N
4W
3W
2W
1W
0
1E
2E
3E
R1W
R1E
Plate 5–2
Aerial Photograph and Study Area Map
MILES
FEET
KILOMETERS
METERS
Explanation
Project Boundary
01-16-01 CAR:[140,150] NRAFUSAP.DGN
RF=NRAFUSAP.TIF


Cavecreek
Carefree
Peoria
Scottsdale
Surprise
El Mirage
Youngtown
Phoenix
Fountain Hills
Glendale
Paradise Valley
Litchfield Park
Buckeye
Tolleson
Mesa
Apache Junction
Tempe
Western Canal
Guadalupe
Gilbert
Avondale
Chandler
Goodyear
Queen Creek
Arizona Canal
Grand Canal
X-Cut
Arizona Canal
South Canal
Tempe Canal
Consolidated Canal
Eastern Canal

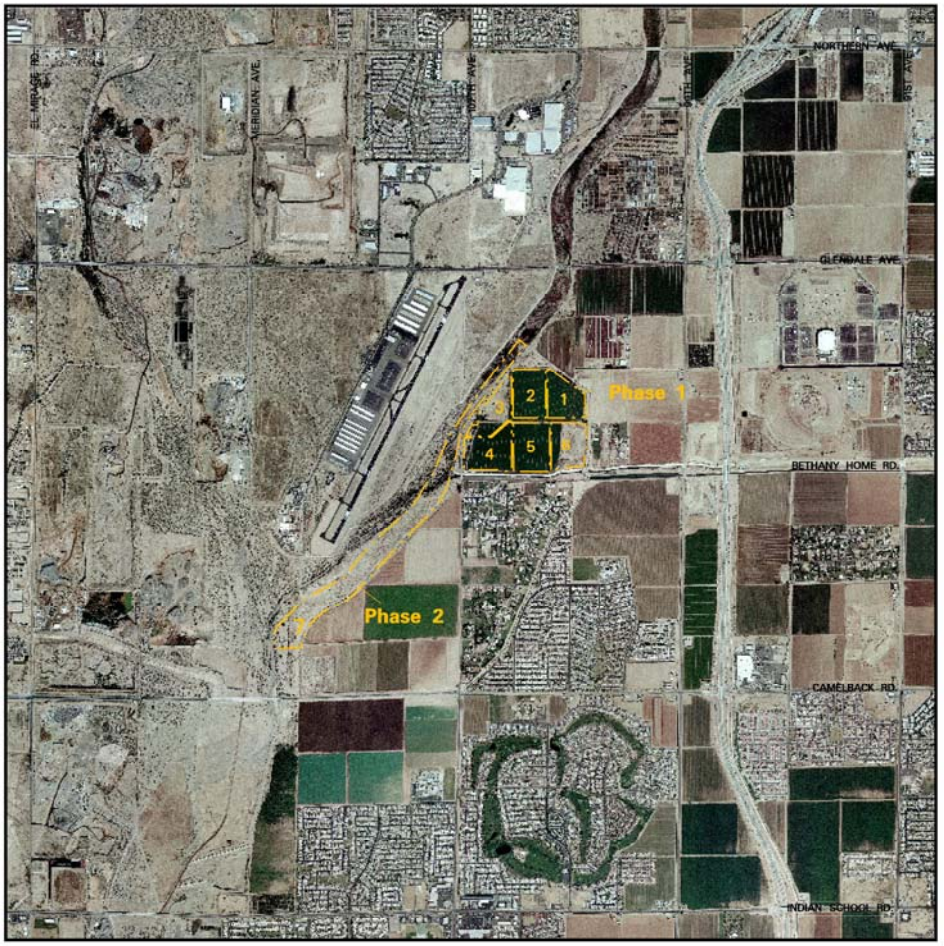


PHOTO: © *AerialExpress October 2003*

Explanation

Project Boundary

Scale in Miles

0 1

R1E

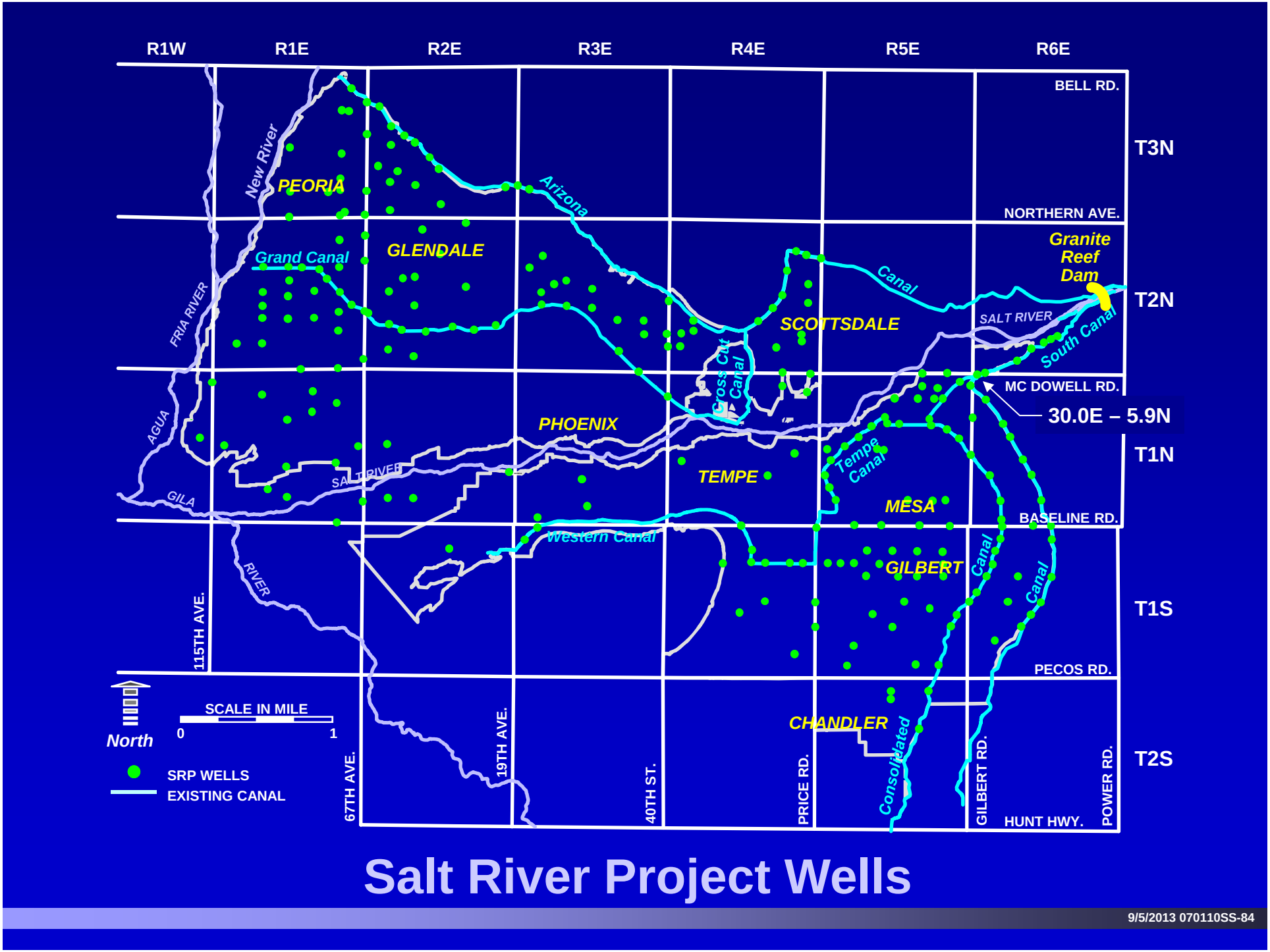
NORTH

Figure 1
Project Aerial Photograph and Site Location

Cartographic & GIS Services

5/3/2004 CAR:[NAUSRP] NRAFUSAP2M.DGN
RF = NRAFUSAP2M.JPG

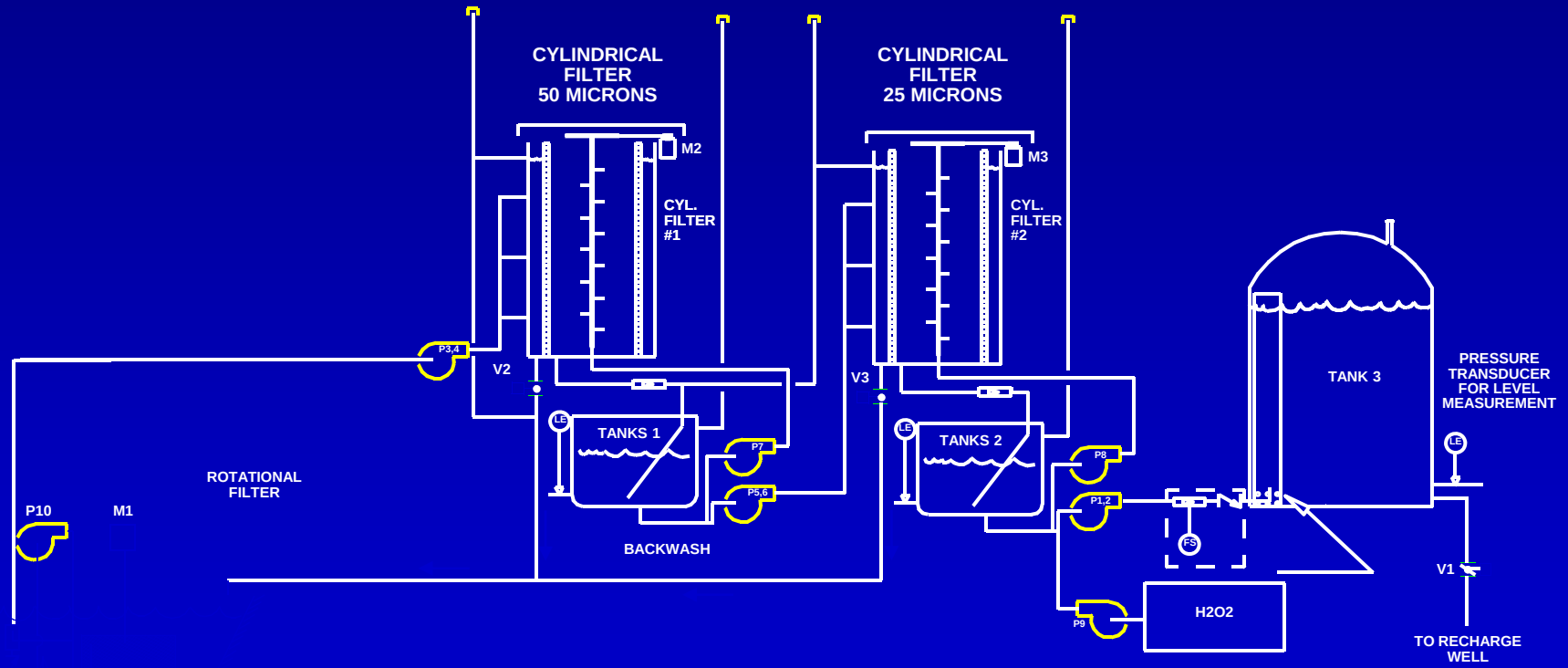
Well Recharge



Salt River Project Wells


M9548

Phase III: Rotating + Cylindrical Filter



Conjunctive Use in Arizona
The Water Campus Facility

- Scottsdale, Arizona
- An AWWT plant: The most advanced technology
  80,000 m^3/d
- A WTP for CAP water: 200,000 m^3/d
- Aquifer storage using vadose zone wells

Conjunctive Use in Arizona
The Water Campus Facility

Functions

- Treat CAP water to potable grade
- Treat municipal effluent to advanced II
- Treat advanced II to potable grade
- Aquifer storage by:
  - Vadose zone wells – SAT
  - Injection wells

9/5/2013 070110SS-89

Conclusions

The use of Conjunctive Water Management will maximize the efficiency and cost-effectiveness of a water system. This water system could be for irrigation, urban, industrial or multi-purpose. The application of this water management practice has been very successful in the semiarid areas of the Southwestern United States but is also applicable in more humid regions